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Progress Report #11-7-50G-1

HESSE - EASTERN DIVISION

FLIGHTEX FABRICS, INC.

PROGRESS REPORT #3

ENGINEERING PROGRAM FOR THE DEVELOPMENT

OF A LIGHTWEIGHT ANTI-TANK ROCKET

NOVEMBER 1957

CONTRACT NO. RD-142

PREPARED BY

Paul V. C.
Paul V. C.

APPROVED BY

Charles B. W.
Charles B. W.

SUBMITTED BY: HESSE-EASTERN DIVISION
FLIGHTEX FABRICS, INC.
CAMBRIDGE, MASSACHUSETTS

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WORK DONE DURING THE MONTH OF NOVEMBER, 1957

REPORTING PERIOD 4 NOVEMBER TO 6 DECEMBER 1957

SYSTEM EVALUATION PROGRAM

During November proper ignition at $+120^{\circ}\text{F}$ and -20° was achieved. Rounds were also tested having four, five and six folding fins. The rounds having four and five fins wobbled towards the end of the flight path, while the rounds having six fins all hit the target and had very good stability. Unfortunately, of the group of rounds fired only three had six fins. A test is planned for early in December to check target accuracy with rounds having six and eight fins. It is expected that this test will show the accuracy of this round. E. M. No. 2 has been evaluated, and some parts have been detailed, and manufacture is expected to begin early in December.

Intensive investigation has been carried out in the past month to determine why such poor penetration was achieved with the ten HEAT heads statically fired in October. An evaluation of the Xrays plus one static test with a perfectly poured HEAT head has shown that the reason is not imperfectly poured charges. It is strongly felt that an increase in penetration can be achieved by an increase in the wall thickness of the copper liner. This conclusion is based upon conferences with various

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authorities in the shaped charge field. Acting on this conclusion, a quantity of fifty liners having an increased wall has been placed in manufacture. It is expected that these liners will be received early in December and that a test will be held with them in the same month. A further result of the investigation has shown that it may be entirely possible to achieve the penetration required through the use of a single angle liner. If a single angle liner is used, the only disadvantage would be that a greater stand-off would be required. This in itself would not be a great disadvantage to the over-all round in that the maximum increase in length expected would be of the order of magnitude of 1" to 2". In view of the time schedule on the project, it is felt that if the next attempt with the increased wall liners to achieve penetration is not successful, then the design would be changed immediately to a single angle liner. This change will permit the design to be frozen and the program schedule met.

Extensive redesign of the launcher was done in November. It is expected that detailed drawings will be made and manufacture started in December.

In November fuzes were fired having rotors. These tests indicated some problems existed when the rotors were introduced into the fuze mechanism. An investigation is currently being carried out to eliminate these problems, and it is fully expected that they will be eliminated by the end of December, or at the latest, the middle of January.

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MOTOR DEVELOPMENT PROGRAM

During November the plastic igniter discussed in last month's progress report was received and tested. Rounds were fired at both - 20°F and + 120°F using this igniter. The table of flight tests' results is shown below:

ROUND NO.	36	37	38	39	40	41	42	43	44	45	46	47	48
VELOCITY (FT/SEC)	286	321	308	276	308	--	250	308	258	320	320	160	380
PROP. WEIGHT (LBS.)	.132	.132	.132	.132	.132	.132	.132	.132	.132	.132	.132	.132	.132
1/2 PROP. WEIGHT	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06
PROJECTILE WEIGHT	3.28	3.21	3.18	3.30	3.21	3.11	3.64	3.72	3.75	3.67	3.47	3.61	3.17
EFF. WEIGHT (4 / 5)	3.34	3.27	3.24	3.36	3.27	3.17	3.70	3.78	3.81	3.73	3.53	3.67	3.23
IMP. (6 X 2) g	29.7	32.6	31.0	28.8	31.2	--	28.7	36.2	30.5	37	35.1	18.25	38.1
SPEC. IMP. $\frac{7}{3}$	225	247	234	218	236	--	217	274	231	280	266	--	288
TEMP. OF	-20°	-20°	-20°	-20°	-20°	-20°	+120°	+120°	+120°	+120°	+120°	+120°	--

REMARKS: Round No. 41 - Motor failed in launcher (plastic launcher)

Round No. 47 - Plastic launcher used - launcher shattered
1' from exhaust end

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On all rounds there was no ignition delay, and recovered charges indicated that complete ignition had been achieved. It is therefore concluded that the problem of improper ignition has been overcome. In order to facilitate assembly, a few minor changes will be made in the igniter design. When these changes plus the changes that will be made to accommodate the percussion igniter (as discussed under the launcher program) have been made, the igniter design will be frozen and a large quantity ordered for test of the final design (approximately 200).

A layout drawing has been made of E. M. No. 2. This drawing can be found in the appendix, Drawing No. D-8162. The material for the motor bodies of E. M. No. 2 has been ordered, and it is expected it shall be received about the middle of December, at which time the motor body will be placed in manufacture. HEAT heads for E. M. No. 2 will be placed in manufacture about the middle of December. It is hoped that the first flight testing with E. M. No. 2 will take place in January. Following is a listing of the major design improvements incorporated in E. M. No. 2:

1. Folding fins.
2. Nozzle inserts of aluminum.
3. Plates and pins of aluminum.
4. Elimination of adapter and union.
5. The use of the motor barrier and threaded steel ring and internal threads on motor body to make the joint between the motor and head.
6. Reduction of the head body wall from .028 to .020.

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The rounds that were used to check ignition were also used to obtain some basic data on the efficacy of the folding fins. The rounds were made up having either four, five or six folding fins. The rounds were fired at a target located at a range of 100 yards. The rounds having four and five fins achieved improved stability over most of their flight path. However, towards the end of their flight path they wobbled, i.e., they yawed visibly. As a result they were drawn off their flight path and missed the target. Only three rounds had six fins. Each of these rounds flew straight without yaw and hit the target. It may be concluded from the evidence of this test that the minimum number of folding fins that is required is six. The next test that will be conducted will employ rounds having six and eight fins. It is expected that this test will show the accuracy of this round in a positive manner, i.e., in mils.

Round No. 48 of the flight tests of this month employed plates and pins of aluminum. Examination of the spent motor indicated that the propellant had burned properly and adhered properly to the aluminum pins. All future rounds will use aluminum plates and pins.

Examination of the steel nozzle inserts that have been fired two and three times has shown little or no erosion. On this basis it appears that it may be possible to make the nozzle inserts out of aluminum that would not be greatly influenced by erosion. The next group of rounds will employ the nozzle inserts made from aluminum. If the aluminum inserts prove to be practical, the design of the motor nozzle may then be changed to eliminate the nozzle insert completely and to form the nozzle contour entirely with the tubing used for the motor body.

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WARHEAD DEVELOPMENT PROGRAM

A proper evaluation of the Xrays taken of the ten HEAT heads statically fired during October was found to be impossible because of a difference in interpretation between various observers. In order to eliminate any differences in interpretation, it was decided to have one of the charges steamed out and repoured with extreme care and thus obtain a charge that all parties would accept as perfect. This was done, and the Xray taken of this head indicated the complete absence of flaws anywhere in the head. This head was then fired statically for penetration. The penetration achieved was 7". This evidence proves rather conclusively that the penetration achieved on the previous test was not due to imperfections in the charge.

Currently with the investigation of the charge, investigation was being carried out to determine if the penetration of the HEAT head could be improved by other means. This evaluation revealed that other projects having the same problem had materially increased penetration by increasing the wall thickness of the copper liner. Accordingly, after consultations with various authorities, it appears probable that an increase in wall thickness of the liner can produce an increase in the penetration without an increase in the O. D. of the head. To check out this hypothesis, a quantity of fifty liners having an increased wall thickness have been ordered and are expected to be complete about the

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middle of December. Twenty-five of these liners will be assembled in the head body of E. M. No. 1 and checked statically for penetration. The remaining twenty-five liners will be incorporated into the head body of E. M. No. 2, and regardless of the penetration achieved with E. M. No. 1, these heads, i.e., E. M. No. 2, will also be fired statically for penetration in order to make a comparison between the penetration achieved with E. M. No. 1 and that of E. M. No. 2. In this way the changes made in E. M. No. 2 can be evaluated within a minimum time. It is expected that regardless of which liner design is finally adopted the differences between E. M. No. 2 and E. M. No. 1 would have to be known before E. M. No. 2 could be finally adopted.

The penetration tests that have been conducted to date have shown a very high percentage of double jets. This phenomenon is a problem that is characteristic of a double angle liner. The effect of a double jet is to greatly reduce penetration. If the double jet can be eliminated from the present design, the desired penetration can be achieved. Basically, there are two causes of double jetting. No. 1 is the misalignment of the two cone angles. No. 2 is the misalignment of the cone in the head body as a result of improper assembly. The manufacturer of the liners used has indicated that there was no misalignment between cone angles. It is now known definitely whether or not these cones were misaligned upon assembly in spite of the fact that after assembly the run-out between the apex of the cone and the I. D. of the head body was approximately .005" T. I. R. When future HEAT heads are assembled, much closer control of

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assembly will be exercised as well as a 100 per cent inspection of the completed assembly before loading.

In this way double jets may be eliminated. If they are eliminated, it is expected that the penetration achieved will be improved over and above the improvement achieved by increasing the wall thickness.

In view of the problems outlined above, inherent to the use of a double angle liner, a further investigation was made of the possible use of a single angle liner. This investigation revealed that a HEAT head having a single angle liner and being of a slightly smaller O. D. than E. M. No. 1 was capable of achieving 11 1/2" of penetration in milds steel. The advantage of this type of cone is its repeatability and simplicity. If tests held in the immediate future with the double angle liners failed to produce the desired penetration and repeatability, a single angle liner can then be chosen that will most probably give the desired penetration, i.e., 10" maximum in armour. The reason that a liner of this type was not investigated originally is that it was hoped that with a double angle liner the average penetration would have been 10" in armour with a possible maximum between 10 1/2" and 11 1/2". In this way the minimum penetration would then have been of the order of 9" in armour. However, in order that the 10" maximum requirement be met within the time schedule allowed, the investigation of the double angle liner may be halted and a single angle liner chosen. Penetration tests that will be held early in January will indicate which choice will be made.

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LAUNCHER DEVELOPMENT PROGRAM

As a result of the exploitation of ideas obtained from the evaluation of the preliminary launcher, a launcher layout is currently in process. The ignition portion of the round-launcher combination has been designed as shown in appendix. (See Photograph No. 29) The trigger assembly has also been designed and may be found in the appendix. (See Photographs No. 30 and 31) The method of holding the round stationary in the launcher consists of (1) holding the round from forward motion by the igniter assembly and (2) holding the round from backward motion by the interference between the head and the inner sleeve. The inner sleeve is discussed under the fuze program because its prime function is to provide safety for the fuze. This tube is placed over the motor section of the round previous to inserting the round in the launcher. Then the round and inner sleeve assembly are placed in the launcher and the inner sleeve firmly affixed to the launcher tube by means of a metal flange at the exhaust end of the launcher tube. A drawing of the inner sleeve, round and launcher assembly will be enclosed in next month's report. A layout is currently being made that will include not only the above-mentioned assemblies but will also include the rear sight as modified and the front sight as modified. Upon the completion of this layout, which is expected in December, details will be made and parts placed in manufacture. It is expected that parts will be available in January to assemble a complete

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launcher for evaluation purposes. It is expected that this launcher will be very close to being the final design. Effort is now being concentrated on the redesign of the back and front sights. These elements ought to be completed early in December which will complete the redesign of the entire launcher assembly. As previously mentioned, it is hoped that following the completion of the launcher layout details will be made and parts placed in manufacture and a complete launcher assembly available some time in January.

OPERATION OF THE FIRING SYSTEM

(See Photographs No. 29, 30 and 31 in Appendix)

As redesigned, the igniter is contained within the plastic housing already designed and tested on the round. The firing pin and firing pin spring are located in the extreme rear position of the igniter housing. The firing pin spring is compressed upon assembly. The firing pin is restrained by a slotted plunger whose motion is perpendicular to the motion of the firing pin. This plunger is spring loaded in such a manner that when the plunger is released it removes the restraint from the firing pin, thus allowing the firing pin to be driven forward into a detonator, which in turn ignites the black powder charge of the igniter and fires the rocket. The plunger is released by means of the trigger. The plunger rests in a groove of a cylinder which is attached to a 1/8" steel

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rod running inside of a 3/8" tube up to the trigger assembly. At the forward end of this rod is a second cylinder. The end of the trigger lies against the back of this cylinder, and as the trigger is pulled backwards, the cylinder is pushed forward, thus moving the plunger restraining cylinder forward and releasing the firing pin restraining plunger to fire the round. The forward cylinder compresses a spring in moving. If the trigger is released after partial movement, the plunger restraining cylinder returns to the safe position.

When the trigger assembly handle is in the storage position, the trigger and guard are completely enclosed and protected. Also in this position a yolk on the handle engages a cylinder on the 1/8" rod which connects the forward and rear cylinders. The yolk is a positive lock preventing forward motion of the rod. The trigger handle is held in place by a strong spring clamp to prevent opening in transportation and rough handling conditions.

In preparing the round for firing, the handle must be grasped firmly and a strong pull has to be exerted in order to overcome the spring clamp holding it. As the handle is turned open into the firing position, another spring clamp engages on to the 3/8" carrier tube to firmly lock the handle in position. As the handle swings away, the trigger and trigger guard come into view and access. The trigger guard is a stationary piece to protect the trigger from accidental firing after the handle has been opened and placed in the firing position.

It is believed that this firing arrangement will be simple,

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efficient, cheap, and above all, safe. Parts are currently being detailed, and manufacture will begin shortly.

During November a round conditioned at $+120^{\circ}\text{F}$ was fired in a 3-foot kraft paper wound launcher tube. The tube shattered for about half its length. The tube manufacturer has indicated that a much stronger tube using kraft paper base can be made. In order to facilitate procurement and eliminate the time-consuming cut and try approach, the manufacturer desired to be supplied with a burst pressure figure upon which the stronger launcher design could be based. It was therefore decided to carry out a firing program using an aluminum launcher, successively reducing the wall until the tube failed. From the data thus gained the manufacturer would be supplied with a burst pressure and wall thickness in aluminum. This information would suffice as a norm for the launcher design. It is expected that these tests will be carried out in December and new tubes manufactured and tested during January.

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FUZE DEVELOPMENT PROGRAM

INTRODUCTION

The activity during November consisted of an evaluation of previous tests, tests of complete fuze vehicles with rotors and finalizing of the safety pin design.

Five fuze vehicles were tried out and tested dynamically, and the results have shown up certain problems.

STATIC TESTING AND EVALUATION

A number of static tests were conducted to ascertain that the rotor would turn and arm when the triggering components set back. The tests were conducted by assembling fuzes without detonators and dropping them in a partly assembled Evaluation Model No. 1 assembly from a height of approximately 3 feet. It was found that this drop was consistently sufficient to set back the triggering components. The results of these tests were as follows:

1. The length of the firing pin point had to be reduced by a nominal amount of 5/1000ths of an inch in order to clear the O. D. of the rotor after set back under all tolerance conditions.

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2. It was observed that the firing pin was inside the unarmed rotor in about 60 per cent of the test rounds. The conclusion was reached that this type of test does not sufficiently simulate dynamic firing conditions to be of any conclusive value. However, the possibility had to be faced that the complete fuze assembly was not working as well as the test vehicle No. 3 used almost exclusively to date.

DYNAMIC TESTS

Five complete fuzes without safety pins were fired on 26 November 1957. The fuzes were placed in rounds used for accuracy tests, and no functioning time is therefore available. The rounds in question are Nos. 42, 43, 44, 45 and 46. The results were as follows:

Round Nos. 42, 43 and 46 functioned when the round grazed the earth. Round Nos. 44 and 45 were duds. Round No. 44 was recovered, and it was found that the firing pin had released, and the point of the firing pin was still in the small hole which is used to hold the rotor in the unarmed position. Round No. 45 showed the rotor held up by the firing pin after having started to turn, i.e., the firing pin was stuck in the rotor immediately adjacent to the hole used for holding the rotor in the safe position.

CONCLUSION

The results of the test are still in the process of being

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evaluated. There are two possible reasons for the two malfunctions which were encountered:

1. That the triggering components set back but that the triggering sleeve bounced off immediately after latching occurs.

2. That separation between the triggering sleeve and the inertia element occurs during the backward motion of the triggering components.

There are different possibilities of overcoming these conditions:

- A. Place some cushioning material at the base of the fuze to reduce the possibility of bouncing.

- B. To increase the amount which the triggering components have to set back by letting the firing pin enter more deeply into the rotor when the fuze is in the unarmed position. This would have the effect that a greater amount of separation occurs between the triggering sleeve and the inertia element. The chamfer at the open end of the triggering sleeve can then be greatly reduced or eliminated. This would permit a greater latitude in motion of the triggering sleeve before the firing pin is actually released.

- C. By decreasing the weight of the inertia element and increasing the weight of the triggering sleeve, the balance of forces in the two components during set back will be changed. When set back occurs, both components travel backward at the same velocity. However, the force with which each component travels backward depends on its mass. With the present design the mass of the triggering sleeve is very much smaller than the mass of the inertia element. By reversing this situation or by making the difference smaller, more reliable functioning may be obtained.

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D. By reducing the over-all diameter of the triggering sleeve, any contact between the sleeve and the bore of the fuze housing will be eliminated. This will do away with the possibility that the sleeve is triggering against one side of the bore and thereby separated from the inertia element.

E. A method of mechanically tying the triggering sleeve to the inertia element is being designed. This would work in such a manner as to make separation between the two components impossible until the latching position has been reached. This method of approach would completely eliminate the possibility of separation during set back. However, if these malfunctions are caused by bouncing, this method would be of little value.

SAFETY PIN

Three methods of making the fuze drop safe have been designed. Drawing No. D-8141 in the appendix shows the design No. 1. This design consists of a pin which is introduced at the base of the inertia element and which makes it impossible for the element to set back until the pin is removed. Removal of the pin takes place by pushing it inward. This motion was to be obtained by a flat spring and pin contained in the mechanism of the launcher. Changes in launcher design, problems of orientation and location and difficulty in manufacturing the components led to this design being abandoned.

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Drawing No. D-8158 shows a layout of the second design of safety pin. The main body of the fuze is clamped between the booster and the motor barrier. It is located centrally in the round by means of a sleeve. This sleeve has two dogs which when in the forward position prevents the inertia element from setting back. The sleeve is connected to a ring located around the outside of the head body by means of three pins. As can be seen in the enclosed drawing, this ring has a tapered face. A safety pin which is held down by the swivel sight prevents this ring from moving backward. Since the ring and the safety sleeve are interconnected by the pins, no motion is possible until the swivel sight is erected and the spring (see drawing) ejects the safety pin. The safety pin can be in any orientation to the round in this design.

Design No. 2 has eliminated the disadvantages of design No. 1. However, the following problems would be encountered with this design:

1. There would be tolerance problems in the location of the safety pin.
2. The problem of obtaining rigid connection between the safety sleeve and the outer ring may prove to be difficult to solve.
3. If this design is to be used, the fuze will not be completely assembled until the outer ring and pins are assembled.
4. As soon as the swivel sight is erected, the round would be in the unsafe position. It would then take only a 2-foot drop to set back the triggering components, turn the rotor and have the round ready to go off upon a very slight jarring. This method was the one presented at the

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meeting early in November. For the reasons above it has been dropped.

Design No. 3 became feasible with the new concept of the folding fins, and it is shown in Drawing No. D-8155. The safety sleeve from Model No. 2 is retained. However, the round is held in the safe position by means of a pin which enters a groove in the fuze body and is located in the safety sleeve in such a way as to prevent sufficient relative motion between the two parts to let the fuze set back while the pin is in the groove as shown on the layout. A compression spring is used to withdraw the safety pin. A sleeve placed inside the launcher and extending approximately $3/8$ of an inch in front of the safety pin and all the way back to the end of the launcher holds the safety pin in position. Forward motion of the round in the launcher will permit the pin to be withdrawn by the compression spring as soon as the end of the inner sleeve has been reached. The folding fins will be folded in such a way that they are contained in the inner sleeve, and they will simply open up further as they go over the step.

This design completely eliminates any orientation problems. The problem of location is simplified. The assembly problem is eliminated in that the inner sleeve is assembled over the safety pin (or pins) and the folding fins before placing it into the launcher together with the rocket. Design No. 3 as shown is being detailed to fit into Evaluation Model No. 2, and components will be manufactured and the design tested for functioning.

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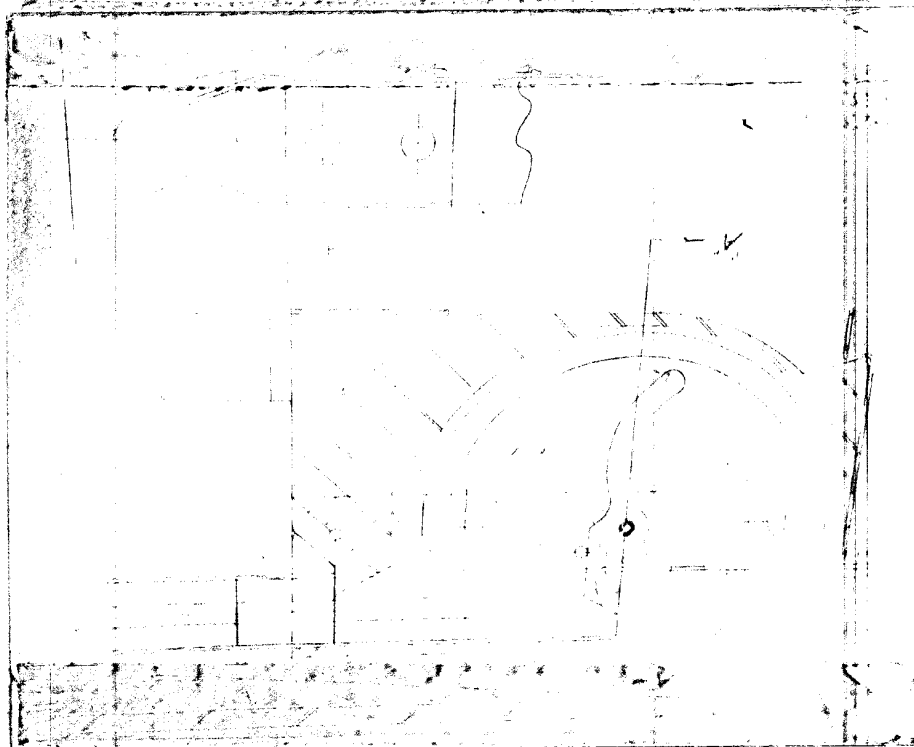
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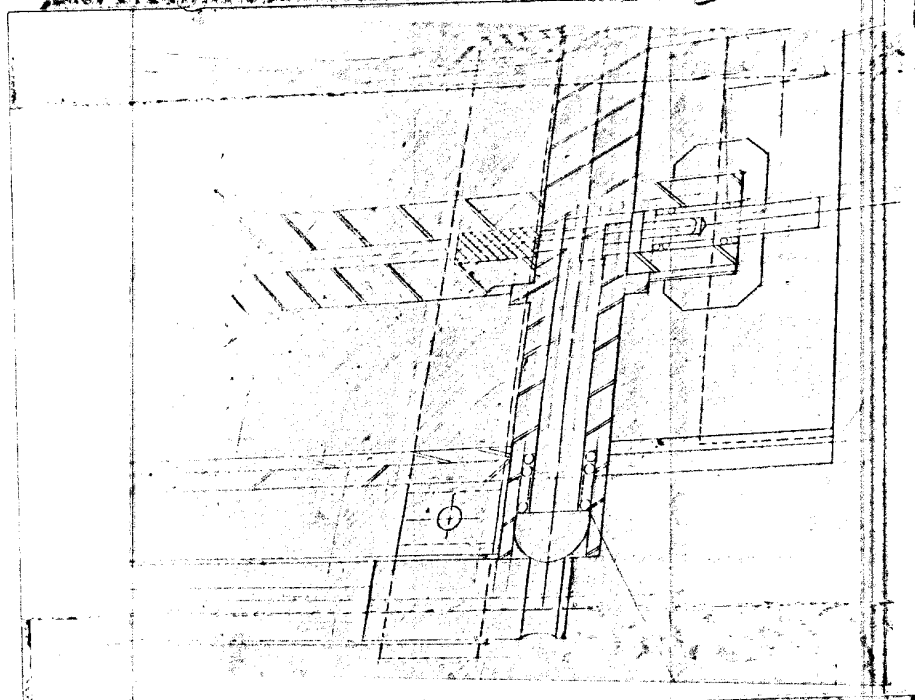
PROGRAM

Parts will be designed and manufactured to eliminate the malfunctioning which was encountered. It is anticipated that the modifications will be minor ones, and can be incorporated in the set of 200 components which were ordered last month. As soon as reliable functioning is established, the operation of the safety pin will have to be checked out by tests. Tests for dynamic train functioning and round penetration using the final fuze design will complete the fuze research and development program.

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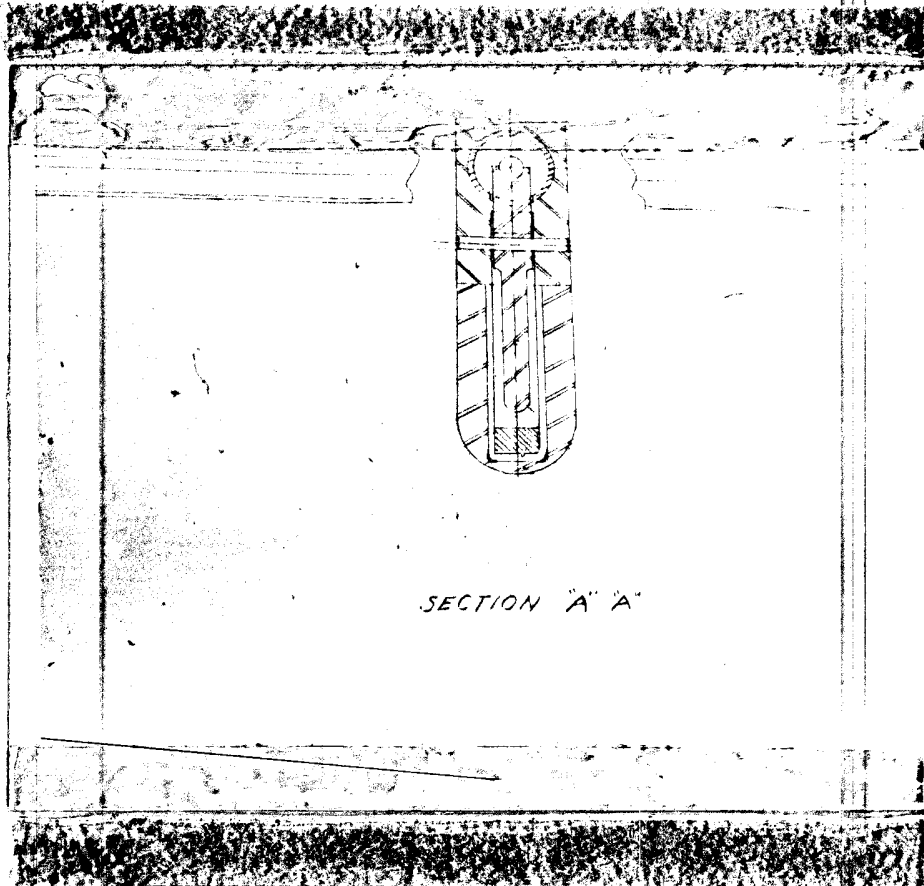
Photograph No. 29
Igniter Assembly E.M. No. 2



Photograph No. 30
Igniter Assembly E.M. No. 2

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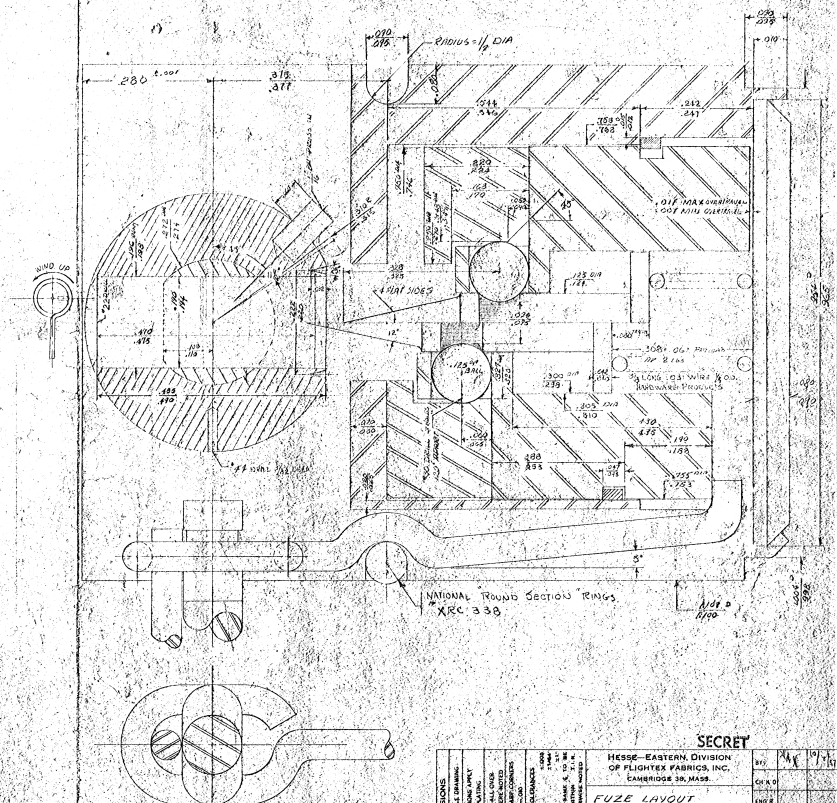
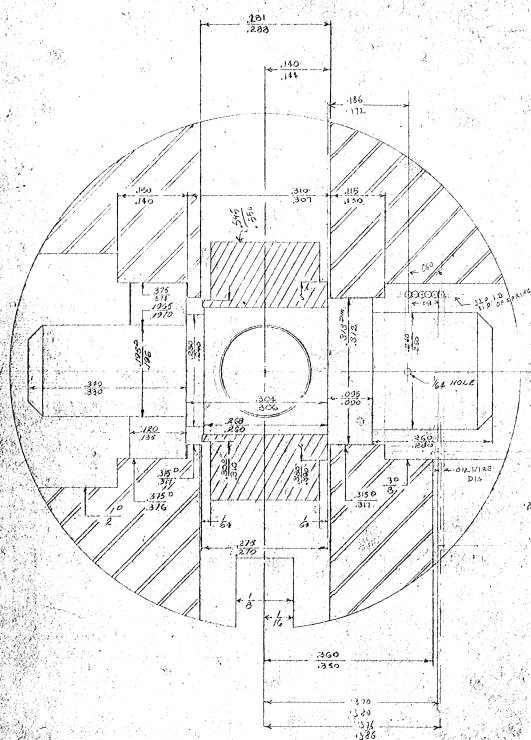
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Photograph No. 31
Section A-A, Trigger Assembly E. M. No. 2

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OF FLIGHTEX FABRICS, INC.
CAMBRIDGE 39, MASS.

FUZE LAYOUT

SHOWING SAFETY PIN #1	
APPROX	10000000

PMO2	ASSI DNG
SCALE 10 X 6	REF DNG

MAY 1

BY:	XX	10/1/87
CH'K'D		
ENG'D		
APP'D		
D 8141		REV D

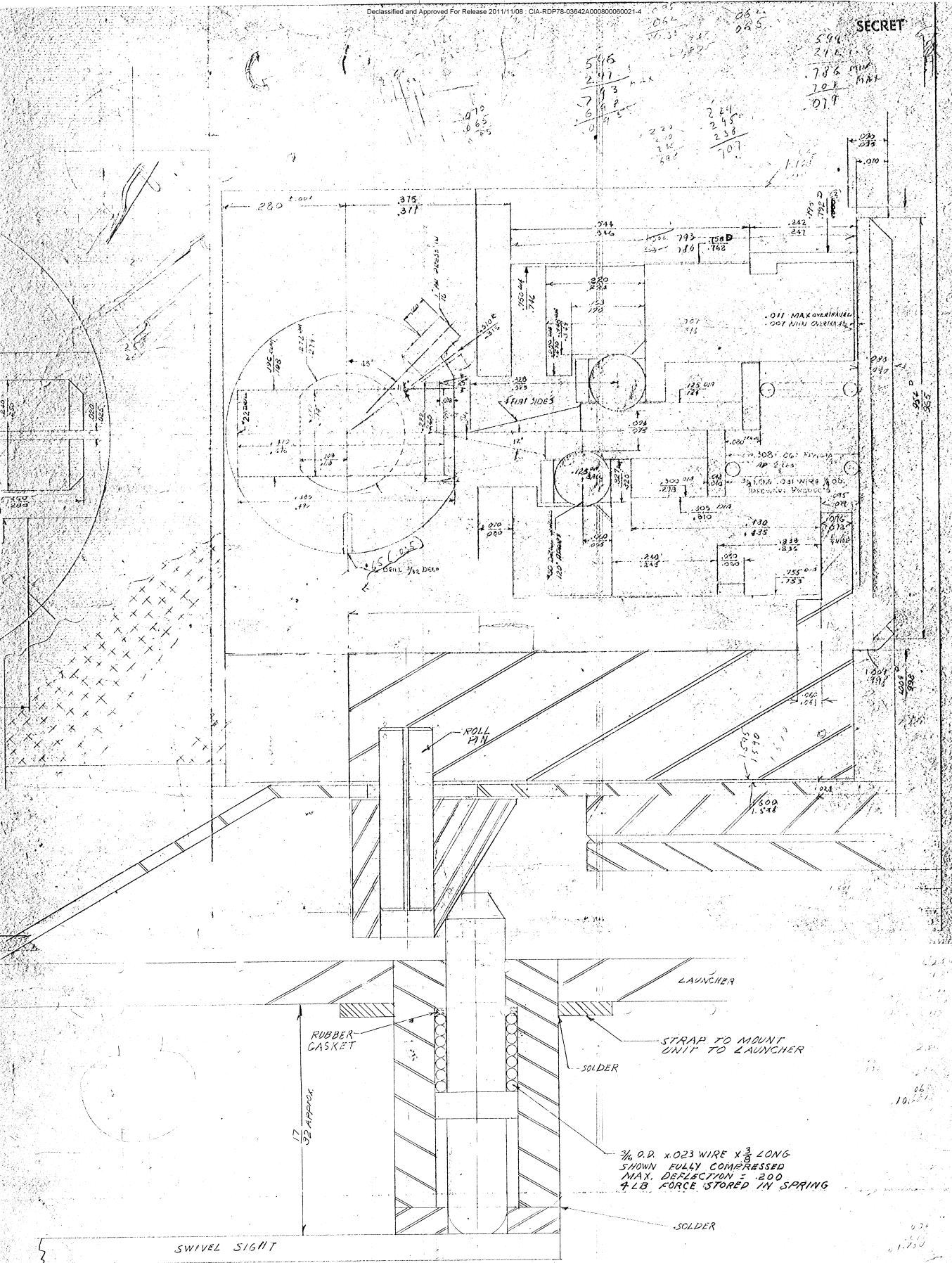
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REFERENCE DRAWING TO RECORD DESIGN DATA ONLY			
RULE LAYOUT SHOWING SAFETY		CLASS	
SCALE BY I.R. 11/57		CONT.	
10 X ENGR. T.B. 11/57		DESC.	
HESSE - EASTERN CORP. CAMBRIDGE 38, MASS.		PROJ.	
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